French Republic

National Institute of Industrial property
Paris
Publication Number: 2 808 127

National Registration Number: 00 05429

International Classification: H 01 q 7/00, H 04 B 5/00

APPLICATION FOR PATENT A1

Deposition Date: 04-21-00

Application Publication Date: 10-26-01 Bulletin 01/43

List of cited documents : see end of document

Applicant: A S K Societe Anonyme- FR

Inventor: Morand Sebastien

Agent: Cabinet Bonneau

Reader antenna for a contactless emitter/receptor system

Summary

This refers to a reader antenna designed for an identification system for access to controlled access areas equipped with a reader for detection of electromagnetic signals emanating from a contactless portable object such as ISO cards or single use tickets (46), said signals are emitted by an antenna (48) located in the portable object in response to electromagnetic signals emitted by the reader when the carrier of the portable object presents the portable object to the reader. The antenna comprises a number k of coil groups arranged in series (40,42,44), each group of coils n is separated from the (n-1) groups by a distance $D_{(n-1)}$ larger than a predefined distance and comprising a number of coils N_n larger than a number of coils $N_{(n-1)}$ of the group of coils n-1 with n varying from 2 to k.

The present invention relates to systems emitter/receptor using a reader designed to detect electromagnetic signals, emitted by a contactless portable object presented by the owner to the reader, in response to electromagnetic signals emitted by an antenna located in the reader. The invention relates more precisely to an antenna of a reader of a contactless emitter/receptor.

The portable objects used for the identification of their owner or for access to controlled access areas such as public transport. For example RATP or SNCF use more and more the contactless technology as opposed to the classical method (cards or tickets) necessitating contact. The latter need to be inserted in a reader to achieve contact that enables the verification of their validity. With extended use , the reader swiping channels wear out making contact with the portable object and the reader very difficult thus forcing the owner to try several times resulting in extended delays.

The exchange of information between the contactless object and the reader is done in general by distance electromagnetic coupling between a first antenna located in the contactless portable object and a second antenna located in the reader. In addition, the object is equipped with an electronic module comprising the first antenna connected to a semiconductor chip that also contains an RF part, a memory in which is stored the information to be furnished to the reader and the processing functions necessary for output and treatment of the information.

In the domain of controlled access to areas, such as public transport areas, there are two types of users, permanent users and occasional users. For the first group, the contactless chip card with ISO format is the best economical solution because the price of the card distributed over the total number of trips over a long period of time is reasonable for the user. But the price of the card becomes too high with respect to the price of the trip for the second group composed of occasional users that buy single use cards.

At the same time like the ISO format cards, there are portable tickets such as those in French Patent 9908802 having a reduced format with respect to the ISO format and being single use only. Their reduced format, leads obviously to a reduced surface for the antenna on the ticket, leading to increased power requirement with respect to the ISO card.

Being that the reader has to work with ISO format cards as well as single use tickets, It is necessary that the power delivered by the said reader is sufficient when the object presented is a single use ticket. A classical reader antenna made of several coils can be sufficient for a contactless object of the size of an ISO format card but insufficient for a contacless object of the size of a ticket.

One solution to this problem consists of introducing a higher filed inside the antenna by adding to this one a small ring comprised of a number of coils designed to increase to a maximum the normal component of the magnetic field emitted in the small ring. Unfortunately, such antenna presents an ergonimical difficulty because in the case of a single use ticket it will function only in the small ring zone. In addition, the normal component of the magnetic field generated by the small ring inside the reader antenna is in opposite phase to the field created by the coils of the antenna thus creating a significant functionality hole for ISO formatted cards when this one is facing the small ring.

For this reason, the main goal of this invention is a reader antenna in an identification system or for contactless access to a controlled access area comprising a reader designed to detect response electromagnetic signals emanating from a contactless portable object such as an ISO card or a single use ticket, said signals emanate from the antenna located in the portable object in response to the reception of electromagnetic signals emitted by the reader antenna when the owner of the portable object presents this object to the reader. The antenna comprises a number k of groups of coils arranged in series, each group n of coils being separated from the group of coils n-1 by a distance $D_{(n-1)}$ larger than a predefined distance and comprising a number of coils N_n varying from 2 to k.

The goals, objects and characteristics of the invention will become clear in the following detailed description and the attached figures in which:

Figure 1 represents schematically a classical reader antenna with several coils showing the magnitude of the normal component of the magnetic field in different areas of the antenna. In what follows the expression magnetic field applies to the component of the field normal to the plane of the antenna.

Figure 2 represents a reader antenna according to the invention comprised of two groups of coils

Figure 3 represents the location of the vertical bits of the coils of a reader antenna according to the invention comprising 3 groups of coils

Figure 4 is a diagram representing the magnitude of the magnetic field in every point located at a distance x from a metallic wire infinitely long in which circulates an electric current.

Figures 5A, 5B and 5C are diagrams that represents, respectively, the magnitudes of the magnetic field generated by the external group of coils, internal group of coils and the resultant magnetic field.

Figure 6 is an example of a diagram representing the magnetic field generated a reader antenna comprising one group of peripheral coils.

Figure 7 is an example of diagram representing the magnetic field generated by a reader antenna comprising several groups of coils according to the invention.

Figure 8 is an example of diagram representing the magnetic field generated by a reader antenna comprising several groups of coils **not** according to the invention.

As indicated on figure 1, a classical antenna 10 comprising a number of coils 12,14,16 generated a variable magnetic field depending on the location. In this manner, in the areas inside the coils the magnitude of the field is positive whereas outside of the coils this value is negative. At a point midway between two coils and if one ignores the magnetic field coming from the other coils, weak, due a decrease with an inverse of distance, the magnetic field is zero because it is the resultant of a positive magnetic field from a bit of a coil and a negative one of the same absolute magnitude from another bit of the coil.

A variable magnetic field is a major disadvantage for generation of electromagnetic signals emitted by the antenna. In fact, the reader surface in front of which is presented the portable object is generally in the form of a square (or rectangle) with sides of 15 to 20 cm. If the antenna is at the very center of this square, there will then be a zone external to the coils in which the field is negative. If on the opposite hand, the coils of the antenna are located at the periphery of the surface of the reader, the magnetic field is positive on the whole surface of the reader (internal to the antenna), but the further one gets away from the coils, the more the magnetic field, which inversely proportional to the distance, decreases. There is thus a dead zone in the middle of the

surface. Thus there will not be enough power received by the portable object if the latter is presented in front of this zone. In addition, the solution consisting of increasing considerably the number of coils to increase the magnetic field is not viable because the surface occupied by the coils increases also thus increasing the number of dead zones.

The solution that is the object of the invention consists thus in using an antenna made of a number of groups of coils in series 1 to n, each group of coils n-1 being internal to the group of coils n. An example of mode of practice is illustrated in the form of two groups in figure 2in which the first group of coils 20 comprises 2 square coils and the second group 22 comprises 4 square coils separated from the other group by a distance D.

If one considers figure 3, representing the left vertical bits of three successive groups of coils 40, 42, 44, the magnetic field generated by the group of coils 40 is negative at the outside i.e, left of the group 40. On the opposite hand, the presence of a group of coils 42, surrounding the group of coils 40, enables the generation of a positive magnetic field inside the coils and in particular in the interval between the groups 40 and 42.

In general, the magnetic field inducted by a metallic wire of dimension l_m in which circulates an electric current I has a magnitude represented by the graph illustrated in figure 4. In the middle of the metallic wire, the magnetic field is null. Then it increases rapidly to reach a near constant magnitude according to the following formula if the origin of abscissa is at the center of the wire:

$$H_i=K_iI/(2\pi l_m) \quad \text{for } 0<x<l_m$$

And the magnitude of H decreases as an inverse function of the abscissa according to the following formula:

$$H_i=K_iI/(2\pi x) \quad \text{for } x>l_m$$

The magnitude of the field generated by a group N of coils is then:

$$H=0 \text{ for } x=0$$

$H_i = K_i NI/(2\pi l_m)$ for $0 < x < l_m$

$H_i = K_i NI/(2\pi x)$ for $x > l_m$

Going back to figure 3, the magnitude of the field generated by each group of coils 40, 42 in the space separating the two groups can be represented respectively by the graphs illustrated in figures 5A and 5B for which the origin of the abscissa is taken in the center point of the coils 42. It should be noted that the field (H_1) generated inside the group of coils 42 (Figure 5A) is positive whereas the field ($-H_2$) generated outside the group of coils 40 (figure 5B) is negative.

The magnitude (H_R) of the resultant field in the space between the groups 40 and 42 is thus the algebraic sum of the field illustrated in figures 5A and 5B. The magnitude of this field illustrated in figure C is then:

$H_R = H_1 - H_2$

As can be seen, this magnitude of the resultant field is first positive, then negative starting at a distance D'_1 from the group of coils 42. If the difference between D_1 and D'_1, for which the resultant field is negative, is not large and much less than the smallest dimension of the antenna of the single use ticket, then it has no effect as long as the average magnitude of the field received by the ticket remains positive and higher than a minimum magnitude sufficient to guaranty the functioning of the ticket. It is possible to reduce this zone to zero by choosing the distance D_1 separating the two groups of coils to be equal to D'_1 a thing that enables one to get a field that is always positive in the space between the two groups of coils. For this reason, the condition is that the maximum absolute magnitude of the negative field $-H_2$ must be smaller or equal to the minimum absolute magnitude of the positive field $+H_1$; this means approximately:

$K_1 N_1 I/(2\pi l_{m1}) \leq K_2 N_2 I/(2\pi D_1)$ or in other words

$K_1 N_1 D_1 \leq K_2 N_2 l_{m1}$

In a first approximation, if one accepts that the two coefficients K_1 and K_2 are equal one then obtains:

$$N_1 D_1 \leq N_2 l_{m1}$$

l_{m1} being smaller than D_1, one can then see that this inequality can be verified by choosing adequate magnitudes of N_1 and N_2 such as :

$$(N_2 / N_1) \geq (D_1 / l_{m1})$$

Or in general for two consecutive groups of coils n and n-1:

$$(N_n / N_{n-1}) \geq (D_{n-1} / l_{m(n-1)})$$

One should note that the positive field generated by the group pf coils 42, adds to the positive field generated by the group of coils inside the coils but in a lesser manner since the field weakens when one gets further from coils 42. With the same token , a group of coils 44 surrounds the group of coils 42. The positive magnetic field generated by the group of coils 44 inside the coils compensates the negative magnetic field created by the group of coils 42 in the zone located between the two groups of coils (but also the negative field generated by the group 40), which enables the creation of a positive or at least an average positive field in this zone if the number of coils is sufficiently important. One should note that the positive field generated by the group of coils 44 adds to the positive field generated by the group 42 and also to the positive field generated by the group 40 inside the coils 40, but less and less being that the distance is more and more important.

In recurrent manner, a plurality of groups of coils comprising an increasing number of coils can be located around the previous groups so that it covers all the surface of the reader destined for the antenna. Furthermore, the parameter that determines the number k of groups of coils of the antenna is the distance between the groups. This distance D_1 between the groups 40 and 42 or D_1 between the groups 42 and 44 should be optimized. It should not be too small to avoid the accumulation of the magnetic fields around the center point as mentioned earlier in reference to figure 1. But the distance cannot be too large either so that the positive magnetic field is sufficient to compensate the negative magnetic field created by the previous group of coils outside the coils.

There is a determining parameter that also conditions the structure of the antenna according to the invention, and it is the fact that the single use ticket should receive an average positive field in every point of a reader and in particular when it is above a group of coils for which the generated field is null. It is thus necessary that the smallest side of the antenna of the ticket be larger than the width of each group of coils as illustrated in figure 3 where the width of the antenna 48 on the ticket 46 is bigger than the total width of the largest group of coils 44. Knowing that the number of coils increases for each group of coils in the direction of the periphery of the antenna, it is thus obligatory that the width of the metal of the coils decrease as one goes from a group to a larger group so that the width of the group of coils is always less than the smallest dimension of the antenna of the ticket. Consequently, the following equations apply to the example illustrated in figure 2:

$$(N_2 / N_1) \geq (D_1 / l_{m1})$$

$$(N_3 / N_2) \geq (D_2 / l_{m2})$$

One should also verify the following equations:

$$l_{m1} > l_{m2} > l_{m3}$$

Respecting the inequalities listed above, it is clear that the more one increases the number of coils of an external group, for instance N_3, the more one can increase the distance separating this group from the immediate internal group for instance D_2. One should note that the distance d separating two coils in each group of coils should the smallest possible, meaning the minimal distance allowed during the manufacturing of the coils. In general, this distance d is an order of magnitude smaller than the distance D. In other words the ratio between the distance D and the distance d should be larger than a predetermined optimum ratio. Consequently, if the width between coils has a given value d this means that the distance D should be larger than a predefined value.

Because of the successive groups of coils, as described above, one can obtain a filed from the reader sufficient for a card as well as a single use ticket. In addition, this situation enables one to obtain a relatively uniform field on the whole surface of the reader that does not surpass a predetermined value of the field higher than the norms

applicable to contactless objects. This demonstrated by the following three examples illustrated by figures 5,6 and 7 where the origin of the abscissa is located in the center of the reader and for which we have considered that:

- The single use ticket comprises a square antenna of 2 cm x 2 cm
- The reader has dimensions 20 cm x 20 cm
- The minimum field to be generated for the card is 0.8 A/m
- The minimum field to be generated for the single use ticket is 2 A/m
- The magnitude of the field not to be exceeded is 7.5 A/m
- The electric current circulating in the coils is 50 mA

1- In the first case illustrated in figure 6, the reader has a simple antenna made of 4 concentric coils, at the periphery of the reader, whose metal width is 1 mm and the distance between coils is also 1 mm. One notices that the maximum field is 15 A/m at the periphery, thus larger than the admissible threshold. Whereas towards the middle of the reader, the field is only 0.8 A/m, thus sufficient for the reader of a card but not enough for the reader of a single use ticket.

2- In a second case illustrated in figure 7, the reader antenna is made of, according to the invention, of three groups of coils:

- A first group of two coils of dimensions 6 cm x 6 cm, with metal width 0.3 cm and an inter-coil distance of 0.1 mm.

- A second group of 4 coils of dimension 17 cm x 17 cm with metal width of 0.3 cm and inter-coil distance of 0.1 mm.

- A third group of 6 coils of dimension 20 cm x 20 cm and metal width of 1 mm and inter-coil distance of 0.1 mm.

One notices that the minimum field is 2 A//m is thus sufficient for reading a single use ticket or a card, and that maximum field is 7.5 A/m and equal to the threshold not to be exceeded.

3- In the third case illustrated in figure 8, the antenna of the reader is similar to that of the second case except that for the third group of coils, the width of the metal is 0.3 cm instead of 0.1 mm.

One notices that the field becomes negative in the space located between the second and third groups , this is due to the fact that the width of the metal was not decreased in the third group of coils whereas the number of coils is larger than that of the second group.

Claims

1- A reader antenna in a system of identification, or access to a zone of controlled access comprising a reader destined to detect response electromagnetic signals emanating from a contactless portable object such as an ISO card or a single use ticket, said electromagnetic signals being emitted by an antenna located in the portable object in response to electromagnetic signals emitted by the reader antenna when the owner of the portable object presents the portable object to the reader. Said antenna is characterized by the fact that it comprises a plurality k of groups of coils (20,22,24) arranged in series, each group of coils n being separated from a group of coils n-1 by a distance D_{n-1} larger than a predefined value and comprising a number of coils N_n larger than the number N_{n-1} of coils n-1 with n varying from 2 to k.

2- A reader antenna according to claim 1, in which the said plurality of groups of coils corresponds to a number of groups of coils sufficient for the antenna to cover the entire surface of the said reader in front of which is presented the said portable object.

3- A reader antenna according to claim 2 comprising three groups of coils (40,42,44).

4- A reader antenna according to claim 1,2 or 3 in which each of the dimensions of te antenna located in the said portable object is larger than the width of the coils of any of the groups of coils.

5- A reader antenna according to claims 1 to 4 in which the following inequality holds between two groups of coils (40,42,44) n and n-1 being consecutive:

$$(N_n / N_{n-1}) \geq (D_{n-1} / l_{m(n-1)})$$

Where $l_{m(n-1)}$ is the width of the metallic wires making the coils n-1.

6- A reader antenna according to claims 1 to 5, in which the ratio D_{n-1} /d is larger than a predetermined value for all n values from 2 to k, d being the predefined value of the width between two adjacent coils.

7- A reader antenna according to any of the claims above, in which the said reader has dimensions of 20 cm x 20 cm and the said single use ticket comprises an antenna 48 of dimensions 2cm x 2cm.

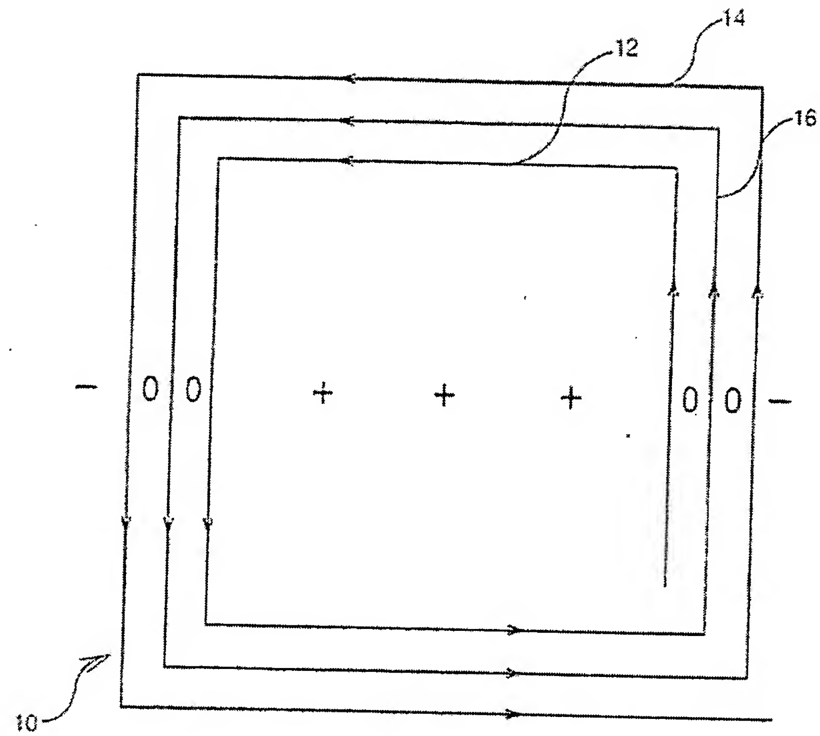


FIG. 1

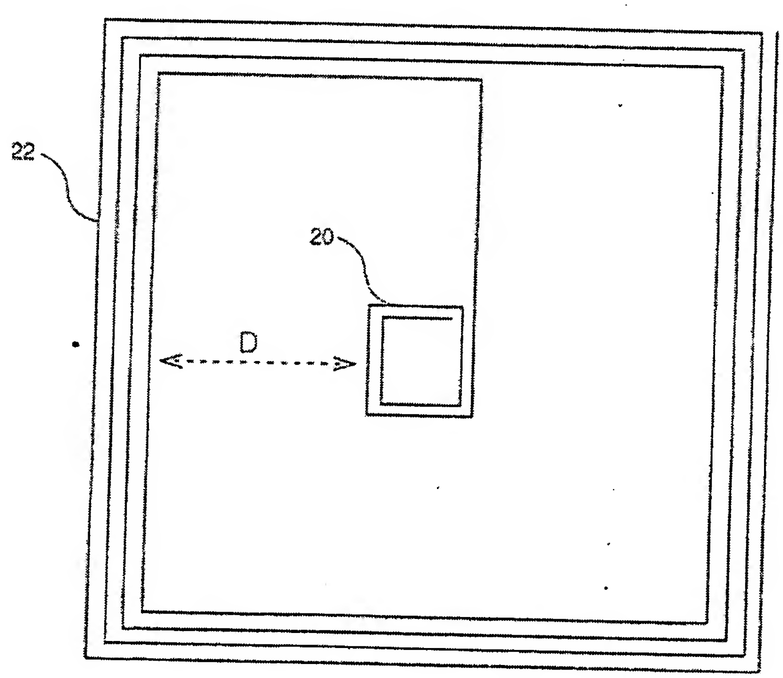


FIG. 2

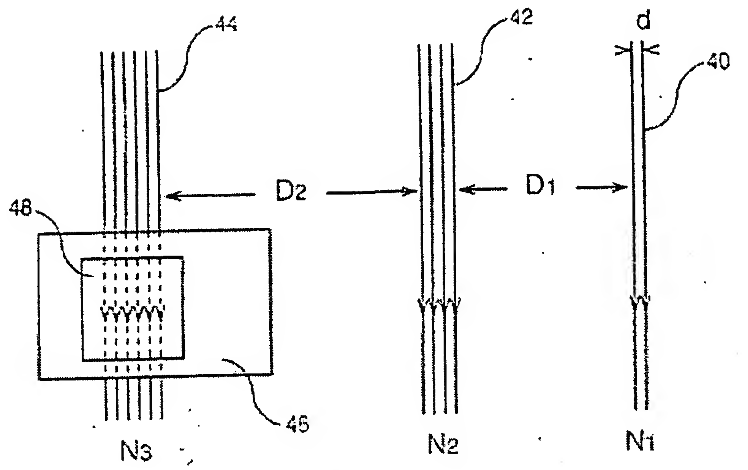


FIG. 3

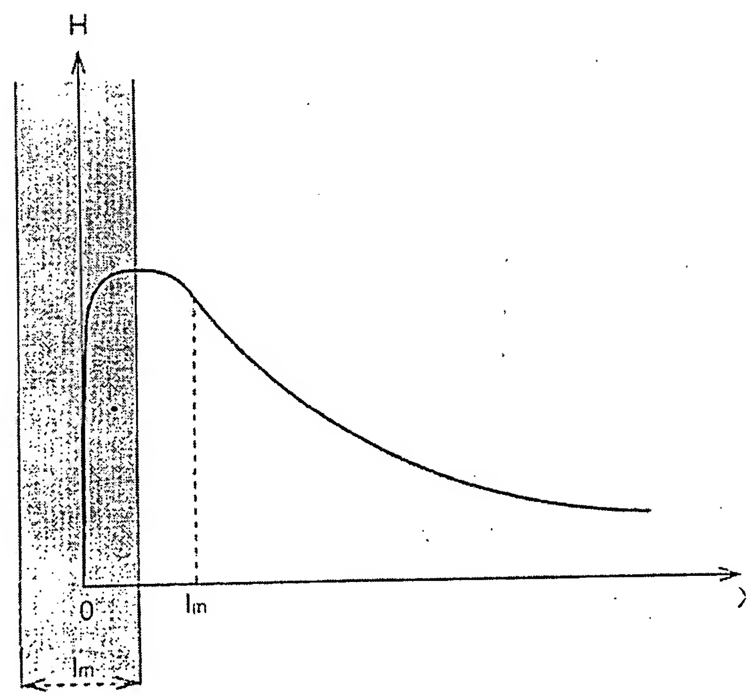


FIG. 4

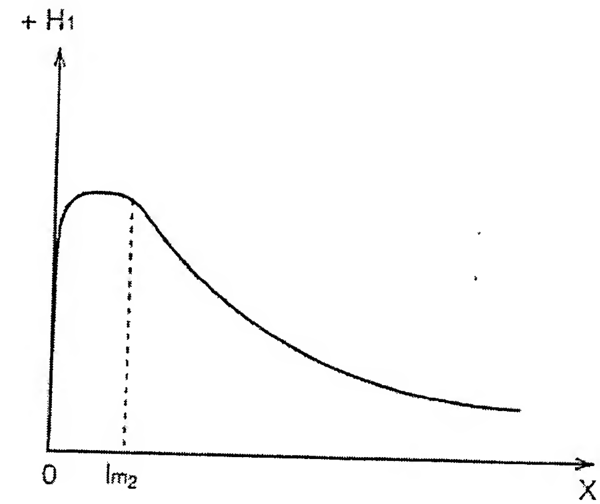


FIG. 5A

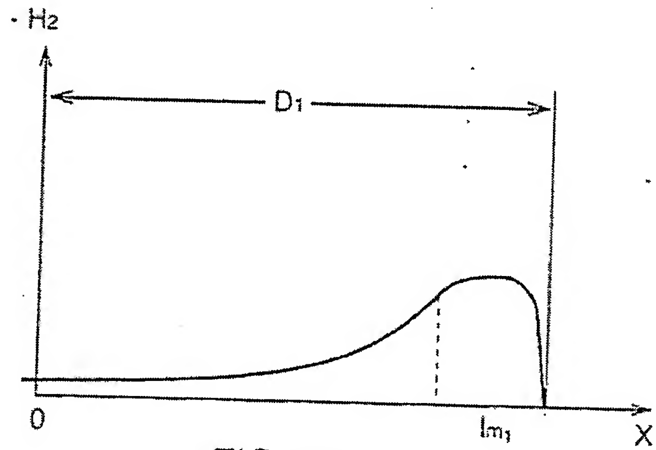


FIG. 5B

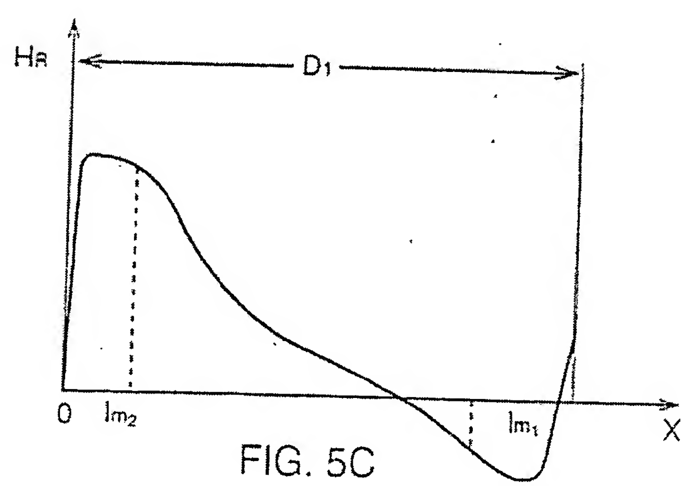


FIG. 5C

BEST AVAILABLE COPY

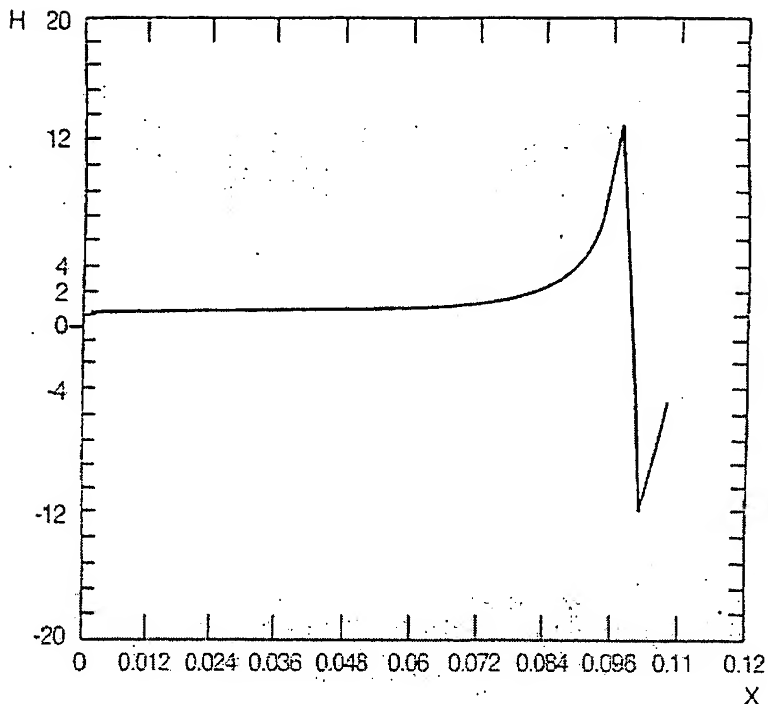

H
20
12
4
2
0
-4
-12
-20
0
0.012
0.024
0.036
0.048
0.06
0.072
0.084
0.096
0.11
0.12
X

FIG. 6

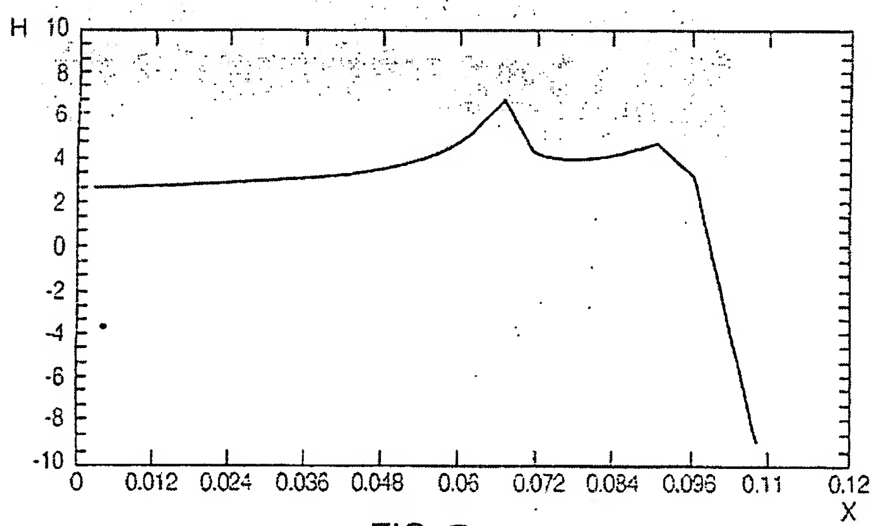
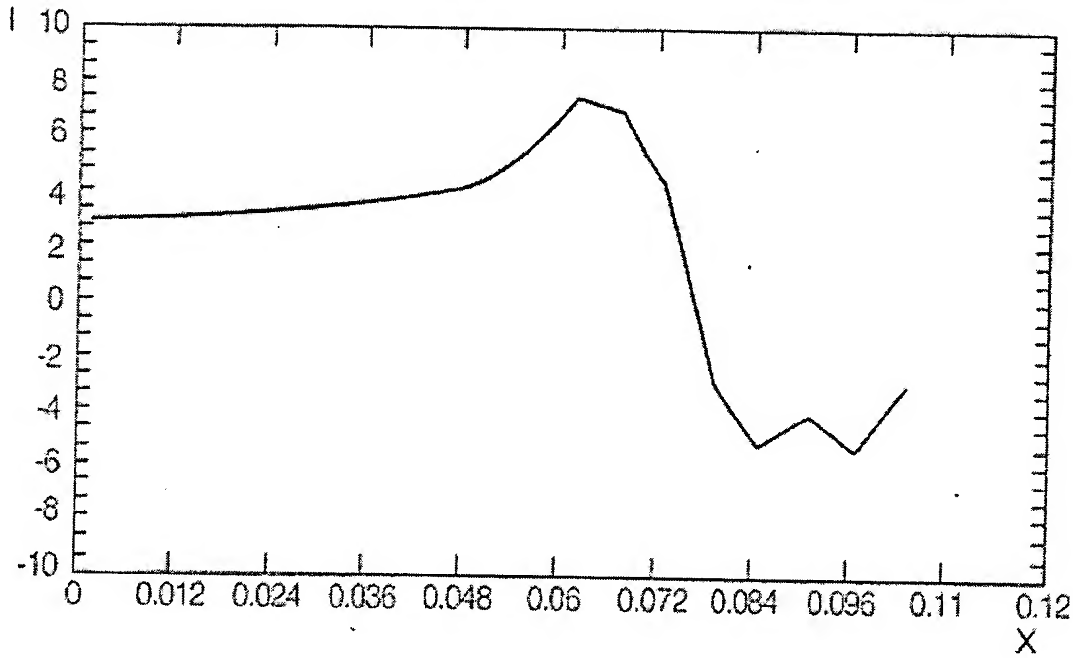

H
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
0.012
0.024
0.036
0.048
0.06
0.072
0.084
0.096
0.11
0.12
X

FIG. 7



I
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
0.012
0.024
0.036
0.048
0.06
0.072
0.084
0.096
0.11
0.12
X

FIG. 8

French Republic

INPI (National Institute of Industrial Property)

Preliminary Research Report : Established on the basis of the last claims delivered before the star of the search)

National Registration Number: FA 590337, FR 0005429

Pertinent Documents		Pertinent Claims	Classification attributed to the invention by the INPI
Category	Citation of the document with indication, if necessary, of pertinent parts		
X	EP 0 768 620 A (Palomar Tech Corp) April 16 1997 *figure 2*	1-6	H01Q7/00 H04B5/00
X	EP 0 766 200 A (SONY Chem Corp) April 2 1997 *abbreviated*	1,2,4,6	
X	EP 0 739 050 A (SONY Chem Corp) October 23 1996 Column 4 line 3-line 18, Figures 1,4	1,2,4,6	
X	US 4 922 261 A (O'farrel Kevin) May 1 1990 Column 3, line 41-line 11, Figure 6	1,2,4,6	
	Search Completion Date: Decenber 22 2000	Examiner Wattiaux, V	Technical Domain searched : H01Q
X : pertinent in itself			

Translated by : Hassan Sahouani
Phone : (651) 737-2552